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Hermean magnetospheric structure shape dynamics

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In this work we investigate the dynamic nature of Mercury's magnetosphere based on fitting parameters of the Paraboloid magnetosphere model (PMM) to magnetic field measurements obtained by the MESSENGER mission during each orbit separately. Earlier work has allowed us to perform data preprocessing in order to remove a number of systematic effects that would negatively impact the performance of our large-scale modelling effort, such as changes in the aberration angle of Mercury's magnetosphere induced by the solar wind that varies strongly due to the high eccentricity of Mercury's orbit; this is important to acknowledge as the data set we process spans over 1 Hermean year.

We take a number of measures in order to reduce the chance or completely avoid the optimization algorithm converging to local minima. First, we run optimization procedure multiple times for each MESSENGER orbit and choose initial variable values randomly in physically meaningful ranges. After running the optimization algorithm the desired number of times, we choose the set of parameters that produces the lowest rms error relative to the observations. Second, we assume that in cases where the magnetosphere of Mercury was not affected with any interplanetary medium disturbances (such as coronal mass ejections) paraboloid model parameters describing magnetic field measurements during consequent orbits should change smoothly and lightly; thus, running optimization of the (i+1)-th orbit from initial parameter values produced during the simulation of the (i)-th orbit, and then running optimization of the (i)-th orbit again from initial parameter values produced during the simulation of the (i+1)-th orbit should converge to the same values as before. Finally, we perform k-means clustering on the space of paraboloid model parameters in order to identify common states of the magnetosphere described by similar parameter values.